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A review on palm oil biodiesel as a source of renewable fuel

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ABSTRACT

The demand of increasing price in fossil fuel has prompted the global oil industry to look at the alternative sources of fuel from renewable energy source which is biodiesel. Biodiesel is considered as better option because of its environmental friendly characteristics while giving almost the same functional properties like fossil fuels.

This paper will focus on the biodiesel produced in Malaysia. Palm oil is the main raw stock for biodiesel production in Malaysia as the country is one of the leading palm oil producers in the world. There are many advantages and disadvantages from the economical social and environmental aspects in the Malaysian biodiesel production in specific palm oil biodiesel. The aim of this paper is to analyze the past, current and future of palm oil biodiesel industry in Malaysia.

This paper includes the technology aspect used in the palm oil biodiesel production and characteristics of pure palm oil biodiesel to meet the international market standard. Malaysia faces tough competition from other biodiesel producers like Indonesia and Brazil. The scope of this study covers the worldwide biodiesel development in brief in continuation with the challenges faced by Malaysia in becoming the top biodiesel exporter in the world with the advantages and disadvantage of using palm oil as the feedstock.

Contents

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1. Introduction

Every form of energy has its own source. In the earth, there are several forms of energy sources such as solar power from sun which radiates energy, nuclear power, wave energy which results from moon gravitational pull and earth geothermal energy which originates from earth's deep core. In comparison of all available energy sources in the world, solar energy is the largest and as long the sun shines; it will remain the largest world energy source [1].

Current world energy situation is heavily dependent on fossil fuels and coal which a non-renewable energy source. These energy sources may deplete in time if proper energy management actions are not taken soon which questions the energy security of the future. The best option to handle this problem is the introduction of renewable energy sources and its increased role in addressing the world energy need.

Increasingly, renewable energy in the form of biodiesel is getting attention from the world countries due to the environment friendly characteristics, while it still able to be diesel engine fuel without requiring any complex modifications to the engine itself. Biodiesel also has its advantage of abundance of raw stock which confirms continuous raw material supply [2].

Biodiesel is an environmentally friendly, renewable energy source that could also produce cost savings for taxpayers and private businesses which is produced from farmers that grow various fuel crops. The drawbacks from fossil fuels like high market price and negative impact on the environment has driven the search for an alternative and renewable energy source. Biofuels are identified as a possible replacement for the fossil fuels where countries like Brazil and US are promoting ethanol as potential biofuel derived from sugar cane and corn [3].

In recent times, world has been paying attention to other biofuels especially biodiesel. European countries are playing important role in import and export of biodiesel. Biodiesel is known as a non-petroleum diesel. It is produced biologically from the vegetable oil and animal fats using transesterification process. Varieties of feedstock have been identified as potential biodiesel raw stocks like rapeseed and soybeans in US and palm oil and jatropha in Asian countries. In recent years, biodiesel from palm oil and jatropha has been identified as renewable energy source with huge potential in the future.

Malaysia is a leading palm oil producer, therefore Malaysia in the past have focused on palm oil as raw stock used for biodiesel production. This paper takes an in depth look at the palm oil used for the production of biodiesel.

Although in the past, several papers have been presented in this subject, this paper differs as it discusses not only the positive side but also the negative side of Malaysian palm oil biodiesel industry. This paper reviews the comparison of Malaysian biodiesel industry with other biodiesel producers analyzing the competitiveness of Malaysia in the world biodiesel market.

Nomenclature

ASTM	American Society for Testing and Materials
CPO	crude palm oil
DBKL	Dewan Bandaraya Kuala Lumpur
DNA	deoxyribonucleic acid
EU	European Union
IFC	International Finance Corporation
ISO	International Standards Organization
MPOB	Malaysian Palm Oil Board
MPOC	Malaysian Palm Oil Council
MYR	Malaysia Ringgits
NGO	Non Government Organization
OSHA	Occupational Safety and Health Administration
POIC	Palm Oil Industrial Cluster
PRIME	Program for Rebuilding and Improving Malaysia's Export
RSPO	Roundtable on Sustainable Palm Oil
UK	United Kingdom
UNFCC	United Natons Framework Convention on Climate Change
US	United States
USA	United States of America

List of symbols

CO_2	carbon dioxide
ml	milliliter
NOx	nitrogen oxide

2. Scope of the paper

Biodiesel production is facing several issues and challenges in the form of tough global competition, feedstock issue, food versus fuel war, sustainability, and limited land for use and deforestation.

The scope of this paper is to collect and analyze the data of palm oil biodiesel in Malaysia. The objective is to determine their performance and their position in the world biodiesel industry, their advantage and disadvantage of using palm oil as the main feedstock for production, political and economic barriers which needs to be overcome, competition between the major producers and technological aspects. This study covers the biodiesel technology that is currently being used in Malaysia to produce pure biodiesel that meets international criteria, suggestions for improvements in implementing better method and technologies to be used in Indonesia and Malaysia. Overall, this paper analyzes the past, current and future trend of the palm oil biodiesel industry in Malaysia among world biodiesel industry.

2.1. Background

2.1.1. Raw stock for biodiesel

There are several sources which are used as feedstock for biodiesel production such as rapeseed and soybean oil. However, compared with other vegetable oil, palm oil has far better advantage and potential as feedstock for biodiesel production. Palm oil is a perennial crop, unlike soybean and rapeseed. Perennial

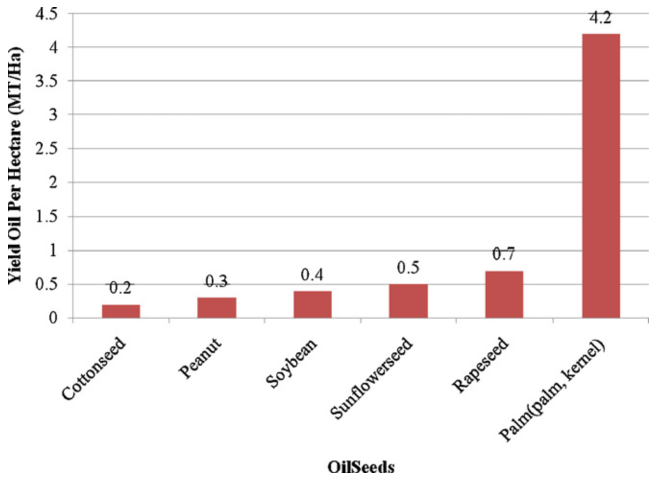


Fig. 1. Yield comparison of major oilseeds [6].

crop means the production of oil is continuous and uninterrupted, though annual production has its seasonal peak and down cycle [4]. Palm plantation has the highest oil yield in terms of oil production per hectare of plantation. Palm oil yield from palm plantation is a factor of ten higher than oil yields from soybeans, sunflower or rapeseeds [5]. Palm oil production has higher production yield compared to soybean, sunflower seed and rapeseed as shown in Fig. 1. Palm oil imports from Malaysia into EU are equivalent to having 4.9 million ha of soybeans or 1.7 million ha of rapeseed [5].

2.1.2. Palm oil as raw stock

Palm oil is the most prospective biodiesel feedstock compared to other oilseeds. As discussed earlier, palm oil has higher production yield, low fertilizer, water and pesticide needed for the plantation. Palm oil production takes less sunlight in terms of energy balance to produce a unit of oil as it produces more oil per hectare. However, in terms of the basis of palm oil yield per man in a day, it is not as competitive as other oilseeds because of the difficulty of labor plantation management and harvesting of the fruit. Comparatively in Indonesia, it is less an issue because the extensive labor market readily available in Indonesia compared to Malaysia [7].

Among the vegetable oils in the world market today, crude palm oil and refined palm oil tops the list. Palm oil is known for its nutrient fact that makes it suitable as vegetable oil used for daily cooking. Palm fruit is known as Elaeis Guineensis. The inner wall of the fruit called mesocarp which is fleshy is required for processing in order to obtain the palm oil. From Fig. 2, it is shown the step by step process of palm oil transformed into crude palm oil which is then processed into other products including biodiesel. Mesocarp is processed into CPO through refining and kernel processing in steps shown in Fig. 2. Amount of CPO obtained from palm is dependent on palm tree variety and also the age of the tree. From a palm bunch, approximately 25–28% of CPO can be obtained [7].

2.1.3. Palm oil biodiesel

The palm oil harvested and produced from palm trees is referred to as CPO. The crude palm oil is the transported to palm oil refinery to be refined. The factory output is the refined palm oil which can be converted into methyl ester and directly used as biodiesel. Another method is by blending refined palm oil with petroleum diesel to make diesel fuel. Blending certain percentage of petroleum diesel with palm diesel is called Envo Diesel. Methyl ester from palm oil has low engine emissions, high oxidation stability apart from the high nitrogen oxide emission which is higher [8].

As shown in Fig. 3, CPO can be processed into refined palm oil which can then be used for multiple applications including be

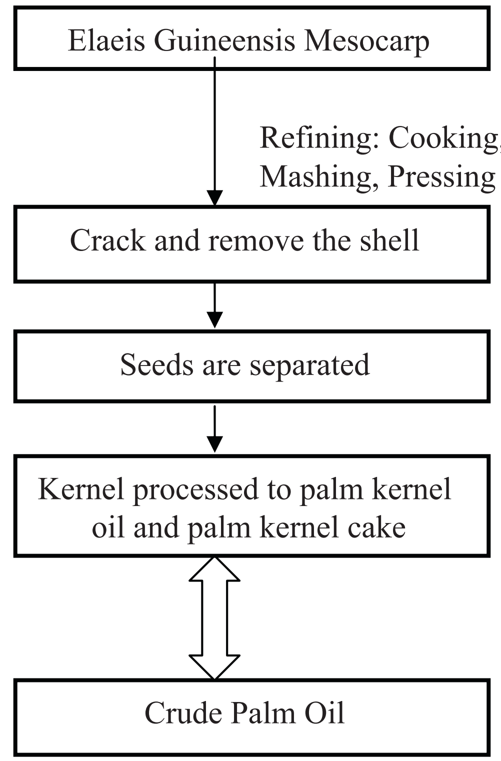


Fig. 2. Palm plant to crude palm oil process.

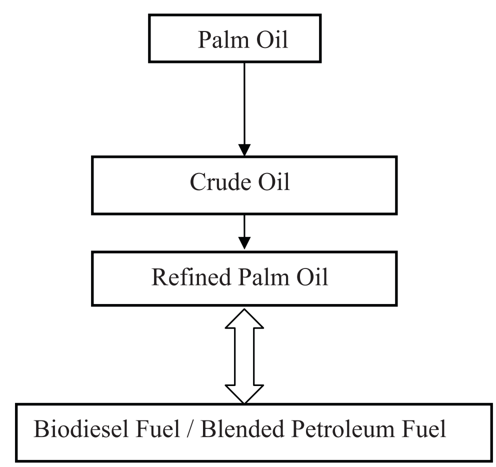


Fig. 3. Palm oil to biodiesel process.

used as palm oil biodiesel. Palm oil is processed into CPO, then into refined oil before being processed into palm oil biodiesel as shown in Fig. 3.

Palm oil biodiesel can be either be processed into methyl ester or blended in certain proportion with petroleum diesel which is known as Envo Diesel. This paper will discuss in detail the Palm Oil Biodiesel.

3. Analysis

3.1. Perspective on Indonesian versus Malaysian palm oil

A significant change took place in palm oil industry in the year 2006 when Indonesia beat Malaysia in the competition of world's leading palm oil producer as shown in Fig. 4. In the current world palm oil production, Malaysia is second largest producer [4].

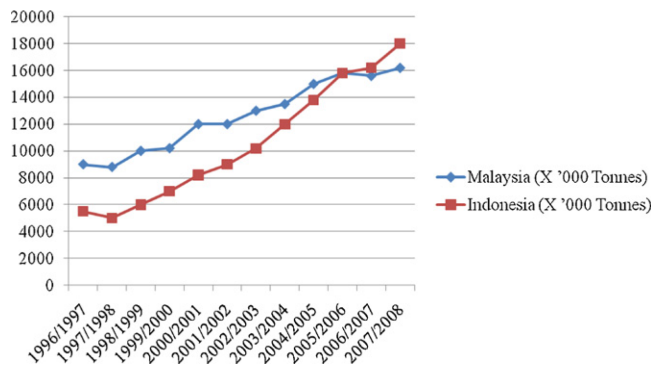


Fig. 4. Malaysia and Indonesia palm oil production.

Looking at the Indonesia's palm oil production rate compared to Malaysia in the below figure, there are high chances of Indonesia surpassing Malaysia and continue to be leading producer for the foreseeable future.

In 2007, Malaysia exported 16.5 million tonnes of palm oil, which is a significant increase of 11% compared past years. This is clearly reflected in the next year; 2008 as the country increased its total palm oil plantation area by 4.3% to fulfill the ever increasing palm oil demand. By year 2008, palm oil plantation area in Malaysia totals up to 4.48 million ha [9]. Compared to growth of 2% in Peninsula Malaysia, the expansion for palm oil plantation is majorly focused on Sabah and Sarawak with growth of approximately 7%. It is estimated that about 30% of total palm plantation area in Malaysia is situated in Sabah with area amounting to 1.33 million ha [10].

3.2. Palm oil biodiesel versus other feedstock

In the year 2008, the government of Malaysia was considering other feedstock as potential biodiesel rawstock for future prospects. Jatropha was identified as high potential feedstock which had suitable criteria as palm oil replacement for biodiesel rawstock. Jatropha as biodiesel rawstock is still in research and development by many countries around the world. It is expected that it will take some time before hitting the commercial fuel market [8].

The government looked at other potential feedstock for biodiesel production due to the competition on the use of the palm oil either as food sources as fuel. Around the world biodiesel producers are now focused in using primarily raw materials which is non-food based for any type of biofuel production to avoid competition of rawstock with food industry. Currently, almost all the biodiesel projects in Malaysia have been focusing on palm oil as the raw material.

During the surface of the reports indicating that EU might ban biofuel derived from crops grown on some sensitive ecosystems, Malaysian palm oil industry feared the worst. Malaysia; as the second largest palm oil producer in the world after Indonesia is the potentially largest palm oil biodiesel producer. Countries like Brazil and the US; biodiesel producer from ethanol are eyeing the EU market giving heavy competition to palm oil biodiesel producers. Biodiesel market are having large market competition after the 27 nation bloc suggested for biofuel to be used at least 10% in transportation by year 2020 [5].

Jatropha is a promising biodiesel feedstock for future. The government publicity on Jatropha as next potential biodiesel feedstock at the Sabah Development Corridor launch in the year 2008 gave competition to existing palm oil biodiesel. However, the use of Jatropha as biodiesel feedstock requires more research to develop its properties to acceptable level for mass commercial usage [8]. And currently, the research is still ongoing.

3.3. Palm oil and Malaysia

The palm oil industry is an important pillar of Malaysia economy. The palm oil sector plays an important role in ensuring a continuous flow of foreign investments and earnings through the export of palm oil and its value added products to the global market. In the year 2008, palm oil industry contributed approximately MYR 65.2 billion in the Malaysia exports which is an evident of palm oil industry significance to the Malaysian economy [9]. The contribution of Malaysian palm oil to the world's oils and fats market was very significant in the year 2008. Malaysia produced 11.1% palm oil; approximately 17.73 million tonnes from global palm oil production which in total of 160 million tonnes oil and fats. The sustainable production of palm oil in Malaysia is overseen by the Malaysian Palm Oil Association. Malaysia palm oil production is estimated 18.3 million tonnes in 2009 compared to 17.73 million tonnes in year 2008 [5].

For last 20 years, there has been rapid increase in global demand for palm oil, especially in food industry, consumer products and recently, for biodiesel rawstock. India and China are countries with growing market that inadvertently increases the demand for vegetable oil. In recent times, world is heavily concerned of the overall energy management and has changed its focus to sustainable energy in which palm oil growth plays a vital role [11]. Foreign investors including European countries have invested millions of dollars in the local palm oil industry to support palm oil biodiesel. European countries are major importer of palm oil; as a step of promoting the sustainable energy in Europe, the government gave subsidies for biodiesel which in turn increased the demand for palm oil significantly. In order to satisfy the demand, palm oil biodiesel producers started to convert rainforest in Asia into palm oil plantation. After clearing the forest and draining the peat swamps, palm plantations are further expanded and developed.

As of the year 2009, the Malaysia palm oil had contributed approximately 26% in the total Malaysian oils and fats export. The palm oil consumption in about 150 countries worldwide is supplied by various palm oil producers; among them, Malaysia supplies about 46% of total oil consumption [9].

This was achieved by using 4.5 million ha of land which is comparatively less than 1.9% of total area in the world used for oilseeds plantation. The total area in the world used for oilseeds is 233 million ha. Malaysia is currently focused on increasing the productivity; steps are taken to increase the oil yields by introducing genome sequencing method. The aim is to increase the average oil yield from four tonnes per hectare to eight tonnes per hectare. Genome sequencing is a laboratory process that determines the complete DNA sequence of an organism [9]. Using this technique, scientific process and procedures can be done to the palm oil plant to produce more outputs. Using this technique, Malaysia is hoping to continue as the major palm oil producer meeting all the global demand without requiring new plantation areas.

The EU are focusing on sustainable energy thus passed a legislation so that all member in EU bloc ship and use palm oil from a company legally approved to produce palm oil that can be used for fuel application in sustainable method. Restrictive policies implemented by EU created differences in the marketing of vegetables and grains 'oil that caused the decrease of the palm oil prices compared to soybean and rapeseed oil'. In November 2008, world's largest palm oil producers; Malaysia and Indonesia jointly agreed and took steps to reduce the palm oil production after huge price fall as an impact from supply exceeding the demand. Among steps taken is replanting old palm plantation, which estimated will reduce about 800,000 tonnes yearly palm oil production.

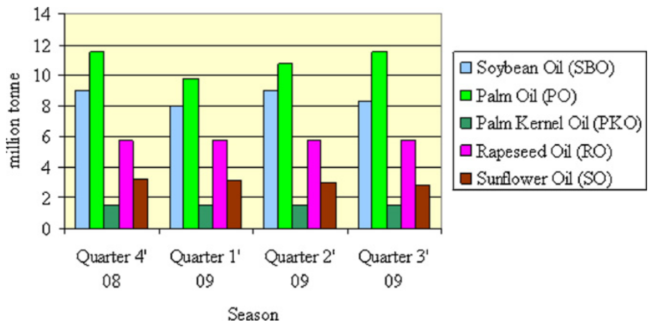


Fig. 5. World production of major oil [12].

In the year of 2009, during the global economic slowdown, Malaysia palm oil industry was facing issue of oversupply. To reduce the oversupply of palm oil and at the same time to support the palm oil prices in the market, Malaysia initiated the Palm Oil Replanting Incentive Scheme worth of MYR 200 million to reduce the nation's high palm oil stock to ensure the stability of palm oil prices. The objective of this scheme is to chop 200,000 ha of palm oil trees aged 25 years and above. For short time period, this is expected to reduce 700,000 tonnes of palm oil supply per year. The government had approved 63,000 ha under this scheme which was closed in June 2009 [9].

Strategies like replanting palm oil tree schemes and impose of the mandate for the palm oil biodiesel use reduces the CPO inventory and helped to sustain its price at MYR 1400 per tonne in the year 2009 [11]. It is important to reduce the oversupply and maintain the CPO price above RM 1400 tonnes as the producers will not be profitable in the trade below this price. In March 2008, the CPO prices soared up till MYR 4180 but the price plummeted to low MYR 1403 per tonne in November 2008 [9]. The inventory for palm oil rose to significantly high amount of 2.3 million in November 2008 but reduced to slightly more than 1.8 million tonnes in January 2009 as shown in the Fig. 5. Palm oil is the major oil produced in the world; this indirectly helps to lower price of palm oil biodiesel but not significantly.

The CPO price range between MYR 1400 and MYR 1900 per tonne in year 2009 was sufficient to sustain the export earnings. However, the earnings from palm oil exports in the year 2009 dropped compared to MYR 65.8 billion in the year 2008 because of the price fall and lower exports.

Towards the end of year 2008, MPOC launched PRIME program. This program is an effort by the MPOC to promote palm oil exports in Malaysia. One of the strategies is to introduce new market perspectives to exporters and encourage them to produce new product innovations to achieve greater business borders [13].

3.4. Biodiesel production technology

Before analyzing the infrastructure and technology required in converting Palm oil into biodiesel, the production process must be understood first. There are three general ways to convert vegetable oils and fats into biodiesel; base catalyzed transesterification of the oil, direct acid catalyzed transesterification of the oil or conversion of the oil to its fatty acid then to biodiesel [14]. Biodiesel producers opt for the option 1 due to low temperature and pressure in the process. This method also has high conversion ratio of almost 98% with minimal side effects and reaction time. This method is advantageous as no intermediate compound is required and the oil can directly be converted to biodiesel [15]. The chemical reaction for base catalyzed palm oil biodiesel production is shown in the chemical equation shown in Fig. 6.

Chemical Equation above shows transformation of palm oil into biodiesel which also gives another output; glycerin. The conclusion from the above chemical equation is that when fat or palm oil reacted with short chain alcohol; methanol or ethanol which is shown as ROH in figure above, glycerin and biodiesel obtained as output. For example, when one hundred kilogram of oils reacted with ten kilogram of alcohol, ten kilogram of glycerin and one hundred kilogram of biodiesel will be obtained as result from the above equation. The alcohol is used to quicken the conversion process. R′, R″ and R‴ shown in the figure above is the representation of the fatty acid chains of the palmitic oil or fat [14].

The biodiesel production process has following steps as shown in the flowchart in Fig. 7:

i. The catalyst mixed with alcohol. The catalyst usually dissolved in the alcohol using a standard mixing machine.
ii. The mix is then put into a closed reaction vessel and the palm oil or fat is added. A closed system is done in the process to prevent the loss of alcohol to the atmosphere.
iii. The mix is kept at the temperature above the boiling point of alcohol at about 70 °C so that the reaction takes place. The reaction time varies from 1 to 8 h and excess alcohol usually used to ensure complete conversion of palm oil into methyl esters.
iv. Once the reaction have completed, there will be two outputs which are glycerin and biodiesel.
v. Glycerin and biodiesel output will not be in their purest form. Each will be in mixture form where it is mixed with excess alcohol from previous steps. This is where the neutralization step takes place. The glycerin has more density compared to biodiesel and the two outputs can be separated using gravity by drawing off the bottom of the settling vessel.

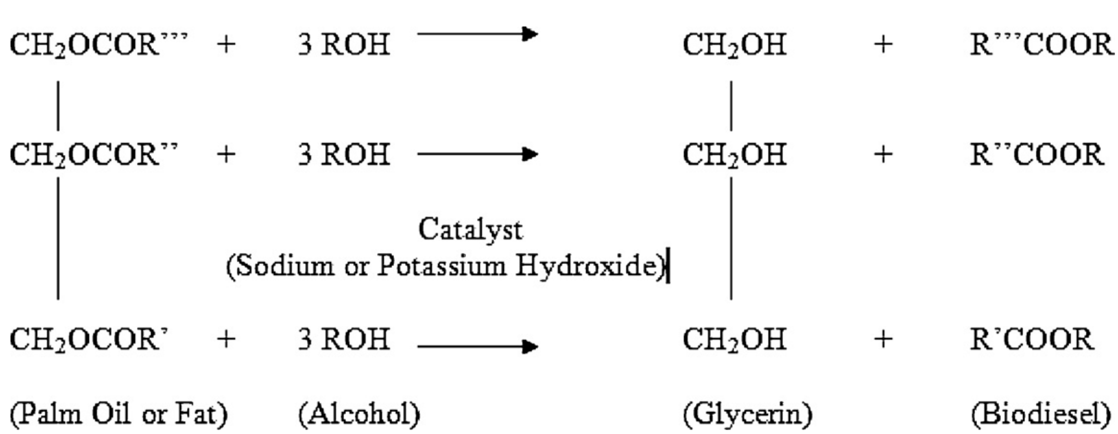


Fig. 6. Equation of palm oil into biodiesel.

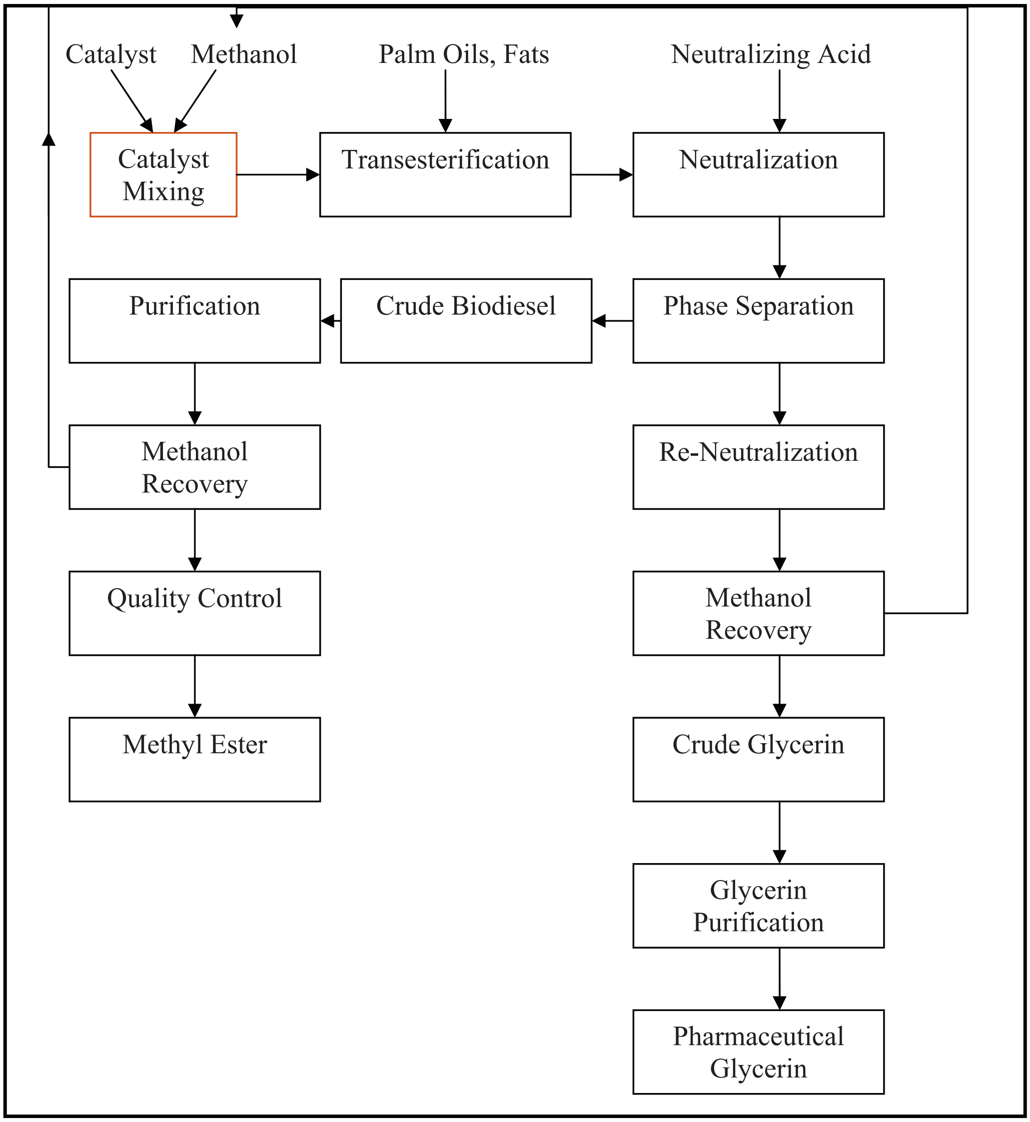


Fig. 7. Biodiesel production process [15].

vi. After the glycerin and biodiesel have been separated, the excess alcohol in each of them will be removed and the mix will be neutralized. The alcohol will be recovered in methanol recovery step using distillation equipment and it will be re-used.

vii. After separation, the biodiesel is further distilled. This is done by washing the biodiesel with warm water in order to remove any type of foreign particles including the catalyst or soaps. Then, biodiesel is dried and stored. The distillation process can be avoided if the output obtained has similar characteristics like petrodiesel in terms of viscosity and yellow liquid color. Biodiesel can be made colorless in one more step of distillation by removing the color properties from the liquid.

viii. For usage as an automotive fuel, the end product of biodiesel must be analyzed using international standard analytical equipment to ensure it meets specifications. For global biodiesel marketing, it is important for a biodiesel manufacturer to register the biodiesel product with the United Stated Environmental Protection Agency under 40 CFR Part 79 [15].

3.5. Pure palm oil biodiesel characteristics

Biodiesel is a biodegradable and non-toxic fuel; free from sulfur. It is produced by transesterification reaction of vegetable oil with low molecular weight alcohol, such as ethanol or methanol. In the industry, biodiesel is produced using homogeneous reaction [16].

Important characteristic of oil to be used as fuel is the solubility of the oil in petroleum. Another way is to blend the oil or fat with the ethanol. Most of the vegetable oils are a mixture of different esters such as oleic acid (main portion from olive oil), ricinoeleic (main portion from castor oil), linoleic acid (main portion from linseed oil), palmitic acid (main portion from the palm oil kernel) and many other oils. Refined CPO makes alternative fuel that is useable in unmodified diesel engines.

As discussed in earlier topics, biodiesel is an alternative fuel that has great potential to replace petroleum fuel. Moreover, it is a renewable energy source which is biodegradable and non-toxic. In recent times, biodiesel issues have drawn lot of interest as increase of depletion of petroleum source in near future is predicted. Currently, biodiesel market is booming in Europe and other countries

like US and Asia have started introducing biodiesel for commercial market as an alternative fuel.

Like discussed earlier, biodiesel can be made from variety of feedstock like soybean, canola, corn, vegetable oil like sunflower and animal fats or waste cooking oils. Fuel made from soybean usually is either used in its original form or blended with petroleum fuel. Blended form of soy based fuel improves lubricity of pure petrodiesel fuel.

Research was done in Bangkok where palm biodiesel was used for a motorcycle, the emission and engine performance was tested. Research found there was no significant difference in emissions between the biodegradable and the fossil fuel. Comparison of the engine performance and fuel consumption for both lubricants showed no significant difference either [17]. However, since palm biodiesel is a renewable source, it is a lower carbon source and that it offers superior tribological properties (wear scar, viscosity index, etc.) [17]. This is a promising alternative to fossil fuels.

Biodiesel plays an important role in country's economy. Biodiesel has the ability to substitute petroleum fuel and dominate the world's transport system. As it is renewable and manufactured using latest technology, biodiesel has bright future in the market replacing old fossil fuels infrastructure and pipes. There has been increasing number of fuel stations selling biodiesel around the world. However, percentage of biodiesel sold versus petroleum diesel is comparatively small. OSHA has categorized biodiesel as non-combustible liquid which burns when it is heated to high temperature. However, when burned, biodiesel fuel releases less toxic and other gases to atmosphere [18].

4. Discussion

4.1. Past and current market trend of palm oil biodiesel

The palm oil biodiesel production in Malaysia is overwhelming. There are initial researches conducted for biodiesel production from various types of sources including waste materials. However, research and development for biodiesel production from waste materials are in early stage and far from being the next energy solution for current and present energy need.

Till the year 2008, Malaysia had about 91% of palm oil biodiesel projects approved to government and non-government companies. In total, these projects had approximately 10.2 million tonnes production capacity per year [9]. Currently, 12 biodiesel plants are fully operational in Malaysia with capability of producing one million tonnes biodiesel per year [9]. There are two other plant having production capacity of 160,000 tonnes a year will start its operation soon as their operational setup has been completed. According to MPOB, the existing biodiesel plants produced approximately 196,363 tonnes between August 2006 and March 2008 while approximately 154,791 tonnes of biodiesel worth of MYR 411 million were exported to countries like US, Europe, Singapore and Australia.

Recently, price of CPO have increased rapidly which impacts the production cost at biodiesel plants. As biodiesel plants in Malaysia are heavily dependent on palm oil as rawstock, increased CPO price has increased the biodiesel production cost. The average cost of CPO in the year 2006 was MYR 1502.50 per tonne. This price has increased significantly within two years; in the year 2007, the price was MYR 2516.50 per tonne while in the early of 2008, the price was MYR 3433.50 per tonne. This has caused the cost to exceed the profit margin.

In March 2008, production cost for palm oil biodiesel was MYR 4330 per tonne; whereas the market price for the palm oil biodiesel was MYR 3632 per tonne. The CPO prices are increasing rapidly as shown in Fig. 8.

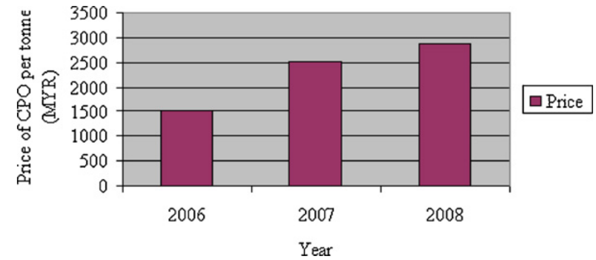


Fig. 8. Rising price of CPO [19].

Continuously rising biodiesel cost have prompted several palm oil biodiesel producers to stop their biodiesel production due to high production cost has left an negative impact on their profit margin. This step in another way have stumped the development and growth of the biodiesel industry.

Till to date, the Malaysian government has given more than 90 biodiesel licences to various organization and companies which has production capacity of 10 million tonnes per year. However, it is reported in the Reuters' survey that on seven biodiesel plants are currently running and most of them are operating well below the capacity. The survey also showed that there were 14 projects delayed; where their total biodiesel production capacity exceeds two million tonnes.

The main reason for the delay is the high CPO prices, which encourages the palm oil industry to produce palm oil for more profitable business or industries instead of the biodiesel which has higher production cost compared to profit. The high cost of investment to setup the biodiesel facilities does not encourage the palm oil industry. It is said that for the priceof biodiesel at MYR 4000 per tonne, even conglomerates in Malaysia such as Sime Darby is not keen to plunge into the biodiesel industry [9]. Currently, the company is focusing on the palm oil downstream activities such as bulking and refinery process to be exported [9].

A report by Frost and Sullivan regarding biodiesel showed that the demand for biodiesel has increased in the Asia region over the past few years. For Malaysia, the demand for palm oil biodiesel would increase from current 110,000 tonnes to 563,000 tonnes in the year 2013. Asia region has a booming market for biodiesel as there are several strong drivers of growth; increased supply and increased demand. Many countries in the Asia region developed domestic markets and at the same time,producers like Malaysia and Indonesia targeted export markets. In several countries in the Asia region, the government introduced mandates for biofuels to develop the domestic market.

On March 22, 2006, Malaysia Prime Minister Datuk Seri Abdullah Ahmad Badawi launched biodiesel called Envo Diesel. This type of biodiesel blends 5% of proccessed palm oil with 95% petrodiesel. In EU, there are B5 type of biodiesel that blends 5% methyl ester with 95% petrodesel. The manufacturers for diesel engine prefer the use of palm oil methyl ester blends as diesel engines are designed to handle 5% methyl ester meeting the EN14214 biodiesel standard [9].

In the year 2009, the Malaysian government reassured that even though high CPO cost, there are no plans to remove the five percent biodiesel mandate introduced in 2006 showing their continuos towards palm oil biodiesel industry. The government encourages the use of biodiesel in the country, although it is not have been mandatory use [20]. Malaysian government are encouraging the use of palm oil biodiesel as they are obliging to Kyoto Protocol. The use of palm oil biodiesel have not been made mandatory due to the fact that at the present,the raw material price is very high.

Kyoto Protocol is a protocol of the UNFCC, an international environmental organization. This organization is trying to achieve

environmental stabilisation. Their main aim is to equalize and neutralize the concentrations of atmospheric greenhouse gas to certain level that can help to avoid degradation caused by human that would disturb the ecosystem and the climate system. In October 2008, Malaysia put into practice the mandate of five percent biodiesel will be used in vehicles starting with the government vehicles in the year 2009 and planning to implement extensively to industrial and transportation sector in the year 2010.

By early 2010, Malaysian government has estimated that nationwide palm oil consumption will be about 500,000 tonnes. This covers three percent of national CPO production. This estimation is the results expected when Malaysia implements the blended biodiesel program full fledged starting with supplying B5 diesel throughout the Malaysia using 36 depots [20]. Government agencies have started using blended biodiesel for official cars; thus promoting biodiesel for transportation. In future, industrial and transportation industry will be encouraged to use the blended biodiesel. The Malaysian government is working with nation's biggest petroleum company; Petronas to provide B5 biodiesel to the other agencies. In February 2009, Kuala Lumpur City Council and the Armed Forces in the country took part in the biodiesel program which proves the government agencies commitment towards growth of palm oil biodiesel industry [20].

As a step forward, biodiesel producers and fuel companies are currently discussing the important aspects and critical issues to the implementation such as logistics and finance. As of the year 2009, the main challenges facing the biodiesel industry in Malaysia are the exports of subsidised US biodiesel to EU that is distrubing the prices and trade, the EU energy directive and overall global economic slowdown.The global economic and financial crisis have caused a significant drop in the CPO prices, causing development of the biodiesel industry to slow down or to be exact halt new investments.

Overall, Malaysia has invested significantly in biodiesel industry achieving production capacity of 1.67 million till date readily available to satisfy the local and world demand. Malaysia together with other palm biodiesel producer; Indonesia is concerned over the idea of EU countries trying to apply taxes on any alternative fuel made from vegetable oils or grains. This proposed idea will bring negative impact to Asian biodiesel producer who depend heavily on vegetable rawstock for biodiesel production. EU have restricted throughout its 27 member bloc countries to import and use alternative fuel supplied by companies that is certified legally to produce palm oil biodiesel with sustainability.

In the year 2009, palm oil had 50% less value compared to year 2008 due to global recession reduced the consumption despite large output and inventory while falling CPO prices caused decreasing demand for biodesels.

4.1.1. Biodiesel projects in Malaysia

In year 2005, Malaysian government introduced biodiesel for transportation use as part of sustainable energy development through diversification of energy sources [21]. Biodiesel is receiving lack of interest from transportation and automobile industry due to unclear policy and directive from the government. Instable palm oil price also hinders the development of biodiesel industry. However, increasing fossil fuel price has revived the interest on biodiesel [21]. Thus, Malaysia government has set their focus to top the biodiesel market by becoming leading palm oil biodiesel producer.

A step that Malaysian government has taken to lift its status in the global palm oil industry and indirectly the palm oil biodiesel industry is by establishing POIC in the year 2005 [9] which is located at eastern Sabah; a place called Lahad Datu. It is located strategically at the palm oil belt of Sabah; a state in Malaysia. This is the first industrial park dedicated fully for palm oil and its business in Malaysia. It is a dream project designed to upgrade Malaysian palm oil industry to the next level in the global competition. The location is neighboring Indonesia's Kalimantan which houses many major palm oil plantations. This place can be considered as an important international frontline for palm oil industry. The initial 1150 acres of the first phase of the project of the 5000 acre gathered overall good responses from biodiesel investors.

Palm oil has been the founding base of the national biofuel policy in Malaysia. The fluctuating palm oil prices have slowed the nationwide execution of five percent palm biodiesel. During the period of year 2006 and 2007, as many as 92 biodiesel projects have been approved but due to challenges and struggles, only 14 biodiesel plants were managed to be built. Among them, only eight plants were in operation in year 2008 [22]. High palm oil prices have stopped other projects on its track. Other plants have stopped their operation or shut down due to heavy loss and unbearable costs [22]. The failure to fully implement Envo Diesel program further dampens progress of the biodiesel industry. These challenges and its negative impacts resulted from the overestimation of projects' output [22]. Government set goals which were lacking in basic technology and practicalities, was merely based on unrealistic assumptions [22]. In the national biofuel policy, government's choice to focus only on one vegetable oil; palm oil shows lack of foresight and planning [22].

Malaysia and other palm oil biodiesel producers in Southeast Asia are focused on palm oil biodiesel export business compared to usage of palm oil biodiesel domestically within their own nation. Comparatively, environmental effects are given less prioritization. All these countries are paying high subsidies for imported fossil fuel. In order to commercialize their own biodiesel, they are required to pay higher subsidies as the biodiesel prices are comparatively higher than the petroleum fuel. Malaysian government have discontinued the Envo Diesel project (the combination of 5% methyl ester with 95% diesel for mass commercial usage) as it has failed to market it at 2008 as planned in "The National Biofuel Policy" launched in year 2006 [8].

4.1.2. Palm oil biodiesel and international standard

In order to achieve a successful biodiesel production operation in terms of producing compatible automotive fuel in unmodified diesel engines, it is important to have complete reaction of the mixture. Like previously mentioned, it is essential to remove unnecessary glycerin, excess alcohol and other unwanted residuals from the output of reaction to obtain pure biodiesel. Before being used as an automotive fuel, the biodiesel must comply with the international standard, ASTM D 6751 [20]. This standard sets the parameters that the pure biodiesel must meet before being used commercially in an automotive.

The importance of meeting the global standard of biodiesel is strengthened by the fact that US; one of major biodiesel importers and user has formed National Biodiesel Accreditation Commission. This commission has an accreditation program to certify eligibility of biodiesel companies. This accreditation is to give assurance and confidence to consumer that the accreditation holder has fulfilled all condition and terms and therefore sells pure biodiesel that meets the ASTM specifications. This accreditation program is being carried out step by step and when the program have been fully implemented, biodiesel marketer all over the world will be recommended to become certified and all biodiesel consumers make their purchases from certified marketers.

4.1.3. Biodiesel development worldwide

The increase of palm oil prices has dampened the fledging biodiesel industry in Malaysia. The government has put on hold the proposed mandatory blend of five percent of palm olein in diesel. However, foreign companies are still investing in this sector considering its long term prospects. The domestic consumption of palm

oil biodiesel in Malaysia is considerably low, so most of all the production will be exported to main importers; EU and the US. Current situation for palm oil as the main raw stock for biodiesel production is not looking so promising with escalating palm oil prices. Alternative raw material; Jatropha is likely to take over the place of palm oil in the case of continuous palm oil price increase.

The rocketing of CPO prices and government subsidy for fossil fuel in the domestic market has prompted some local and foreign investors to temporarily stop their biodiesel plant constructions plans [20]. A couple of Malaysian plants are also suspending production to avoid incurring losses. Also, the Malaysian government also postponed the proposed mandatory blend of 5% of palm olein in domestic market which was proposed in National Biofuel Policy in 2005.

Foreign countries like EU and US are still welcoming the petroleum products and other biofuel products, but recent concerns expressed by EU regarding environmental effects caused by palm oil plantation in long terms may lead to banning of palm oil biodiesel [20]. This raised fears among palm oil biodiesel producers that the product will be banned from entering into EU market which will cause great loss to the producers considering the fact that EU is one of the major biodiesel importers.

However, the debates over the positive and negative impacts of the palm oil biodiesel industries are ongoing everywhere. Biodiesels are often linked with the increase of food prices. In the year 2008, Dr Patrick Dixon, a leading business consultant also known as futurist said that the World Bank has reported about 15% of food price hike is related to energy and fertilizer price increase while about 75% is linked to demand from biodiesel industry.

According to a letter by World Bank President Robert to NGOs, starting from year 2009, the World Bank has temporarily deferred all IFC finance to support palm oil industry. This will be reviewed in time to ensure that all their finances were not misused unintentionally causing social or environmental damage. This policy was drawn as aftermath from a procedural violation by Wilmar Group, a plantation developer. An independent environment group conducted audit and found the developer; who was funded by IFC violating procedures and causing damage to environmental and social standard. This inadvertently has brought World Bank under heavy criticism for supporting palm oil industry which brings deforestation in Indonesia in large scale, which causes greenhouse gas emissions, endangering rare and charismatic species of wildlife, including the orang utan, and displacing forest communities. In a letter to Marcus Colchester, Director of the Peoples Program, Zoellick said the IFC has suspended all new investments in palm oil projects and ordered a review of existing projects until a new strategy is set to ensure the lending is used for good cause effects [23].

In the year 2008, Germany has reduced their subsidies on biofuel. This results in drop in business for biodiesel industry in Malaysia causing biodiesel producers to stop their operations. The impact was also seen in Germany where many fuel stations were forced to suspend their operation due to unbearable cost. But, in January 2009, the situation was reversed where Malaysia and Indonesia saw increased palm biodiesel production. This was due to palm oil price dropped 75% compared to January 2008 [8].

Indonesian government launched their national policy on biofuel in the year 2006. The main aim of the policy was to replace ten percent of transport fuel with alternative fuel by year 2010. This policy was mainly supported by national oil company PERTAMINA where the company started selling B5 biodiesel blends commercially. However, the company was not able support the policy when it incurred heavy financial losses due to high feedstock price of biodiesel. In order to balance losses, the ratio of the blend was reduced to one percent. This overall effect has influenced Indonesian government to reevaluate and adjust their target goal to an achievable target of 2.5% diesel replacement by biodiesel and 3% gasoline replaced by ethanol in 2010 [8].

Compared to other countries, Thailand did quite well in achieving their target of replacing ten percent diesel by biodiesel by year 2012.By year 2007, there were already approximately 800 retail fuel stations selling B5 blends. Indonesia and Thailand makes a stable progress in biodiesel industry as they have multiple feedstocks like sugarcane, cassava as feedstock for biodiesel. In the other hand, Malaysia is focused on palm diesel, causing it to be dependent on petroleum and palm oil price. Also, palm diesel is facing heavy competition from food industry for palm oil to be used as vegetable [8].

4.1.4. Global Competition for palm oil production

Malaysia is one of the leading producers of palm oil biodiesel with extensive reserve of raw palm. On analyzing the track records of biodiesel production by Malaysia one can comment that Malaysia is having a competitive edge over the other palm oil based bio diesel producers. But Malaysia is not the only producers of biodiesel countries like Indonesia, Columbia, Benin, Kenya and Ghana has began to explore the resources available in their country to sustain the palm oil biodiesel production.

Indonesian producers have increased the production of palm oil to supply to the global demand spurred by biodiesel, as supported by the government to become one of the top producers of palm oil. Statistics indicate that the production increased by approximately 400% between the year 1994 to year 2004. In the year 2007, it has been a golden landmark to Indonesia as they outplayed all the other palm oil producers including Malaysia and became the top palm oil producer.

Colombia has grown to be a largest palm oil producer for US with 35% of its product is exported as biofuel. In year 2006, it was reported that cultivation of oil palm was expanding with a few million hectares of area. In addition to Columbia areas which are suitable for cultivation of palm to grow with plantations, the government has identified the opportunity for making use of the wet lands of western Africa and south Benin. The Benin government has identified the economic benefit of producing palm oil based biodiesel in spite of the fact that it will be competing against the domestic food production.

Ghana has a wide variety of palm based species which are marketed only to the local and neighboring counties but because of the low financial position and economic backwardness, Ghana is not able to effectively become a top producer in the export of palm oil. Based on statistics, it is very clear that the immediate competitor to Malaysia in palm oil production is going to be Indonesia as it also has extensive amount of palm cultivation area. The other producers are still exploring all the possible options to increase the production of palm oil and there is a strong possibility that the other producers can develop the production drastically. Hence, it is important for Malaysian government to sustain the palm oil based biodiesel development.

4.2. Challenges and steps taken by Malaysian government to sustain palm oil biodiesel development

Malaysia being a top producer of palm oil based biodiesel has a significant advantage in biodiesel production. In order to sustain and remain in the same position among the global competition there are several hindrance factors which need to be addressed at the right timing. The major factors are:

4.2.1. Cost standard of palm oil biodiesel

Biodiesel production was earlier based on petroleum and later it has been identified as an opportunity to produce the same from palm oil. Hence; in order to promote the palm oil based biodiesel,

it is a necessity to keep the cost of biodiesel from palm oil to be as low as possible on comparison with the petroleum based fuel. On comparing the Commodity market prices of fossil fuels and vegetable oils it is very evident that the commodity price is not in favor of later one. Since the base oil is the main ingredient which is required for the production of biodiesel, it is not going to be easy to produce palm oil based biodiesel in a market with expensive pricing to replace the petroleum based fuel.

Major cost of production in biodiesel market involves approximately about 80% of raw material cost and the remaining 20% for the other manufacturing and production costs. Due to this reason of oil prices it is the profitability in the palm oil based fuel market is estimated to be very low.

As of 24 Mar 2009, palm-based biodiesel was sold at about RM2.80 per liter compared with about RM1.70 per liter for diesel. In order to ensure that Malaysia sustain the alternative source of palm based biodiesel it is important that the government attracts the oil companies and other private companies to produce and market the palm based biodiesel. For this Malaysian government has already implemented a solution in 2009, in order to stabilize the local palm oil industry by allocating MPOB Palm oil stabilization fund to support the biodiesel prices. Even though the CPO prices hits the profit in this sector to a greater extent Malaysia and Indonesia has made a joint collaboration of allocating 40% of the total palm oil production in order to combine with the existing petroleum diesel in order to further promote the palm oil biodiesel.

4.2.2. Export barrier

In first half of year 2009 alone, Malaysia exports almost 150,000 tonnes of palm oil biodiesel to other countries as shown in the Fig. 9. Malaysia exports palm oil biodiesel to several countries like EU, US, Singapore, Taiwan and other countries as shown in the Fig. 10. EU is considered to be one of the largest consumers of biodiesel as shown in the Table 1 [24]. EU has increasing demand for biodiesel; therefore it is important for Malaysia to capture the EU market to become top palm oil biodiesel exporter.

A renewable energy directive has been targeted by Europe foreseeing the achievement in the year 2020. The targets which are foreseen are given below.

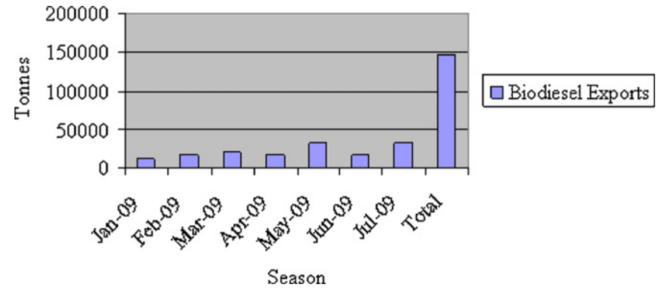


Fig. 9. Malaysian biodiesel exports [9].

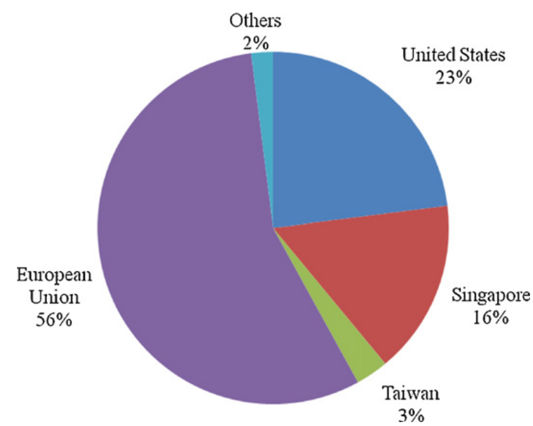


Fig. 10. Malaysian biodiesel export destinations [9].

i) 20% of energy consumed across the EU should be from renewable energy source.
ii) 15% of energy across UK should be from renewable source.
iii) 10% of energy used in transport should be from renewable source.
iv) Minimum reduction in greenhouse gas emission from road transport should be reduced to 6%.

Table 1
Consumption of biodiesel in the European Union [21].

Country	Year 2005 (tonnes)	Year 2006 (tonnes)	Year 2007 (tonnes)	Year 2008 (tonnes)
Germany	209	342	393	335
France	46.6	80	164	273
United Kingdom	3.4	18	37	94
Italy	23.3	20	18	75
Spain	3.1	7.32	35	70
Poland	1.8	5.71	3.38	46
Netherlands	0	2	30	27
Austria	10.7	45	26	25
Portugal	0	9.51	18	18
Sweden	1.1	6.08	14	18
Belgium	0	0.12	12	12
Hungary	0	0.05	0.27	10.96
Czech Republic	0.4	2.48	3.8	10.25
Greece	0.4	6.28	10.99	10.23
Romania	0	0.37	5.41	8.14
Slovenia	0.7	0.56	10.42	7.18
Lithuania	1	1.88	5.69	6.19
Luxembourg	0.1	0.07	5.63	5.61
Ireland	0.1	0.09	2.34	5.41
Slovenia	1.3	1.73	1.76	3.01
Cyprus	0	0	0.1	1.92
Finland	0	0	0.01	1.55
Estonia	0	0.08	0.07	0.37
Latvia	0.3	0.2	0.23	0.26
Malta	0.1	0.12	0.24	0.13
European Union	304	551	798	1.069

As per the new directive set by EU, it is expected to maintain a certain set of standards for the minimization of carbon emission which is expected to go out of the limit which is prescribed because of the highly biodiversified land of Malaysia. In addition to this, indirect land use change because of planting the crops should also be taken in to account which can increase the emission which can cross the required threshold. There is a degree of risk thus there is a possibility of Malaysian based palm oil biodiesel companied can get disqualified for the Exports. Even though Malaysia is not directly involved in exporting biodiesel to Europe but still they have to position themselves in future in international market standard in order to promote and liberate the free trading of palm oil biodiesel subject to ISO.

4.2.3. Government incentives

On analyzing the production mechanism and the cost associated with biodiesel production, one can infer that the profit drawn from this segment is comparatively low which has hindered the growth of the Malaysian biodiesel industry in domestic scale. Private sector companies are generally profit oriented which are not focused in operating a production which is of less profitability in the market space. Unless the government enters in to the market to regulate and motivate the private sector companies in the form of infrastructure, tax and reduction of commodity prices the private parties will not promote the biodiesel growth in the domestic market. The government has granted license for 91 Biodiesel companies under the sponsorship of Investment Act 1986 with the privilege of pioneer status or ITA. The advantage of this status is that the license owners can be granted a tax exemption on 70% of its income for five consecutive years. Certain regions of Malaysia especially Peninsular Malaysia states are granted with a maximum of 100% exemption on statutory income in promoting the trade across all the locations in Malaysia.

In spite of introducing such a privilege, the Malaysian biodiesel industry growth is moving backwards because of ineffectiveness of policy, unrealistic goals and inevitable reaction from the government failing to deal with dynamically changing commodity market. The Licensed companies are not monitored frequently to ensure that the standards and the proposed operational policies are maintained properly failing which the license should be cancelled.

Malaysia is an active member of RSPO; an organization to promote the growth and use of the sustainable palm oil [25]. Malaysia needs to review the policy enforcement for biodiesel and tighten the governance mechanism in accordance to RSPO guidelines to motivate the biodiesel developers to sustain the growth of biodiesel market. Malaysia palm oil industry is committed towards sustainable palm oil production and development; however there is a need for strategies that will guide palm oil producers towards sustainable production and development [25].

The legal framework which has been established by Malaysian government under Malaysian Biofuel Act 2006 was passed by the Parliament in the year 2007. The Act contains provision on the standard for blending biofuel with the petroleum diesel which can be amended by the ministry. The Implementation of B5 based methyl ester biofuel has been introduced for government vehicles commenced from February 2009. Nationwide implementation of the biodiesel usage is expected to be introduced before the end of 2010.

4.2.4. Research and development

Malaysia is currently one of the largest palm oil producers where the nearest competitor production wise is Indonesia. The palm oil cultivation in 2008 is estimated to about 4.48 million ha of area for which 17.73 million tonnes were produced. Palm oil and oil palm biomass are considered to be the major feedstock for biodiesel and development in Malaysia. Biodiesel productions in Malaysia were conducted in three different phases where the first generation palms biofuel which consists of palm biodiesel with different characteristics. Normal grade biodiesel production was started in 1981; winter grade biodiesel production was established in 2001, RBD palm oil with petroleum diesel in a considerable blend to form a mixture which can be used as an alternative to diesel.

The development of winter grade palm oil was technological innovation which overcame the possibility of using the biodiesel for countries which has very low temperature. The Problem which was faced by low temperature was the ignition was not as quick in normal grade biodiesel where the low pour point of winter grade biodiesel attracted the exports to the EU and other countries. The commercial production of winter grade biodiesel using a patented process was established by MPOB in 2006. There demonstration plants were built by MPOB with a capacity to produce about 60,000 tonnes per annum of normal grade biodiesel and 30,000 tonnes per annum of winter grade biodiesel. Malaysian government has realized the potential of biodiesel for the future hence, the per annum production of biodiesel and the infrastructure required for production are established sequentially. As per the July 2009, census taken for the capacity of biodiesel plants established in Malaysia under production is estimated to be 14 with a total production of 1,972,000 tonnes per year yield. There are 5 more plants which are constructed which were able to yield about 250,000 tonnes per annum.

MPOB has established the research of decoding the DNA of the palm oil seed in order to increase the yield by simulating the life cycle of the palm fruit based on different stages of maturity. It was observed that the pattern was matching the simulation for young palm fruit but not for the matured ones. The research on the DNA extraction is continuing which is expected to produce the ground breaking innovation which can avoid in planting a huge area of land for oil palm production, increasing the yield and reducing the cost. The negative impact of genetic modification technology possibly will continue to raise concerns for Malaysian government which needs to be mitigated intelligently and efficiently in the future.

4.2.5. Feedstock for bio-diesel

On knowing the importance of the palm oil which is of abundant quantity of supply from Malaysia, the market prices of approximately between 2500 and 2600 MYR indicating that using palm oil as a feedstock for production of biodiesel will hit the Malaysian economy. The major problem in using palm oil as feedstock are the fluctuation in palm oil and crude oil prices, negative profit margin from this segment and increase of vegetable oil prices in relation with the palm oil since there is a diversified usage for palm oil in variety of applications.

The possible ways forward to this scenario would be [26]:

i) vertical integration of palm biodiesel production;
ii) production of value added products from palm biodiesel;
iii) alternative feedstock in place of palm oil which can be easy to be sustainable.

The allocation of 40% of annual production of palm oil will fuel the increase in prices with demand to the vegetable oil which needs to be mitigated by the Malaysian government or alternative feedstock such as jatropha, sunflower and soybean needs to be used as alternative feedstock for production of biodiesel. From the current policy and projections set by EU, it is clear that many of the Malaysian biodiesel producers can be rejected by the preliminary conditions of highly biodiversified land.

From the current competition India and China are progressing vigorously to capture the market as this is considered to be a potential market for the future exports. Malaysia has already shifted the focus from palm oil to the alternative feedstock called jatropha

which is the feedstock used by other growing biodiesel producing countries. Malaysian government must work hard to strengthen the base of palm oil biodiesel industry and at the same time also develop other feedstock to sustain the growth and competition of biodiesel industry without focusing and heavily dependent on one feedstock; palm oil for Malaysian biodiesel production. The planning, efficiency and effectiveness of the government to change their focus in palm oil biodiesel industry to a more advanced level which includes multiple feedstocks for biodiesel production will determine the growth and success of Malaysian biodiesel industry.

4.3. Advantages of palm oil biodiesel for Malaysia

Palm oil biodiesel have brought lot of advantages to Malaysia from social, technology, environmental and economy aspect. Palm oil biodiesel is apt as the replacement for petrodiesel as it does not require any engine modifications and reduces greenhouse has emission [4]. The combustion of palm based biodiesel does not increase the level of CO_2 in the atmosphere. CO_2 is one such green house gas which is responsible for increasing the global warming [11]. Hence, comparatively the world will have more benefits in the using the palm oil biodiesel instead of fossil fuels as engine fuel. Palm oil biodiesel has advantage of having less engine emissions. However, study proved that palm oil biodiesel releases considerable amount of NOx emission to atmosphere [11]. Palm oil has more oxidation stability than Jatropha and other biodiesel feedstock. The palm biodiesel would increase NOx emission, however this can be reduced by 80–90% with installation of catalytic converters in biodiesel powered vehicles [27].

Palm oil biodiesel also has the advantage of being a sustainable renewable energy, as the main raw stock; palm oil is a renewable resource on comparison with fossil fuels which will deplete in near future as fossil fuels are non-renewable resource. Palm oil can be sustained by re planting the palm seeds to restore the palm plantation.

Another advantage that palm oil biodiesel industry has brought upon Malaysia is the technology development. Palm oil biodiesel industry in Malaysia has achieved a ground breaking technological innovation by developing winter grade biodiesel which is suitable for operations in countries where the pour point is low. The production cost for palm oil biodiesel is lower compared to fossil fuels giving the cost advantage for the palm oil biodiesel.

Palm oil biofuel are biodegradable meaning they are safe to handle. Any spill over will be easier and cheaper to clean up which is not the case with fossil fuels. In the economy aspect, palm biodiesel provides major revenue in the form of exports contributing to the growth domestic product of Malaysia. The infrastructure for palm oil biodiesel is already setup in order to produce about 60,000 tonnes of normal palm oil and 30,000 tonnes of winter grade palm oil. Research and development centers are established in the form of MPOB and MPOC which is frequently reviewing the new product developments [13].

This is an important and crucial solution for environmental problems as it is more suitable for the current world energy scenario. Palm oil biodiesel brings energy security, environmental stability and also rural development for the country by reducing the dependency on petrodiesel, shifting to agricultural industry [2]. In social aspect, palm biodiesel brings advantages as the industry provides job opportunity and social developments to rural area residents as they become important part of the palm biodiesel industry. The development in the industry indirectly helps to increase the living standard of the villagers in Malaysia whom mostly are palm tree estate workers.

4.4. Disadvantages of palm oil biodiesel for Malaysia

As discussed earlier topic, palm biodiesel brings many advantages to Malaysia. However, not all is good in the palm biodiesel industry in Malaysia. There are few disadvantages in the palm biodiesel industry such as the negative effect on the environment. One main negative impact of palm oil biodiesel industry is deforestation. Deforestation of forest land for the use of palm oil plantation is causing negative impact to the environmental balance for Malaysia in the ecosystem [25]. Surge in palm biodiesel industry have created a roadblock for the effort for rainforest conservation in Southeast Asia as people are interested in making money by turning it into palm plantations rather than reserving them as forest to preserve the environment.

Also, the plantation of palm oil has begun to spread nationwide due to development of palm oil biodiesel. This is causing endangerment to exotic animals like orang utan extinction as the animal species has begun to reduce with the increased land usage for palm plantation [25]. It is estimated that palm oil plantations area usually will have the capability to host approximately 15% of flora and fauna species. There are usually more species in undisturbed rainforest compared to disturbed forests or other plantations [28].

When palm plantations are built replacing forests, huge sacrifices are made in terms of environmental balance as carbon stocks cycles are disturbed. It takes extreme long carbon payback time when palm plantation replaces forests and peat lands which has abundant supply of carbon. Even when plantations are built in normal lands filled with grass, clearing process will release large amount carbon that can only be equalized by years of carbon savings provided by usage of palm oil biodiesel in transportations [28]. Also, reduction of CO_2 emissions by palm biodiesel may well be varied with actual implementation [29]. So, the claim of environmentally friendly palm biodiesel is not valid if palm biodiesel is not used with correct practice [10].

Almost 40% of palm oil produced in Malaysia was reserved for biodiesel. This was causing competition between food industry and fuel industry for palm oil as their raw stock. Palm oil reservation for biodiesel cause heavy increase in the demand for vegetable oil for the remaining sixty percent. There is a possibility that the vegetable oil prices can beat the palm oil prices in the near future. There is a huge challenge Malaysia facing in keeping sufficient palm oil as raw stock for biodiesel and edible oil simultaneously to ensure food and energy security. High and fluctuating CPO prices causes' low profit or negative profit margins for palm oil biodiesel producers as the production cost is relatively high. In recent development, EU policy on the environmental pollution control measures may disqualify many of the Malaysian biodiesel producing companies. In the other hand, there are tough competition exist in the industry as Malaysia is not the only major producer, where Indonesia is equally producing biodiesel with increased land usage. In the year 2006, Indonesia topped the production thus moving Malaysia to the second largest producer. This may happen again if Malaysia biodiesel producers fail to secure the business from EU importers.

5. Conclusion and suggestions

5.1. Conclusion

In summary, biodiesel is an environmentally friendly fuel which can be used in diesel engines without any modification. If the biodiesel developed efficiently for energy purpose, it would benefit the environment and the local people by creating job opportunity and provision of modern energy carriers to rural people.

Biodiesel production is facing several issues and challenges like tough global competition, feedstock issue, food versus fuel war, sus-

tainability, and limited land for use and deforestation. Malaysia is far ahead in the development of palm biodiesel compared to all the other countries in the race with current available infrastructure, feedstock reserve and technological balance.

In current situation, Malaysia is sustaining all the challenges and issues. In future, palm biodiesel might be replaced with other feedstock diesel or biomass energy as palm diesel may face feedstock availability issue.

5.2. Future of biodiesel

Biodiesel fuel is being recognized and boasted as the alternative fuel that would replace fossil fuel satisfying the world transportation need and at the same time bring benefit to environment. Since the developed countries started realizing the depletion of fossil fuels which is estimated to dry up in 50 years time, the race for sustainable biodiesel production has begun. The advantages which are given by biodiesel apart from sustainable production; they reduce the carbon emissions to a greater extent, adds more job opportunities pertaining to economy and environment, reduces the need for import of fossil fuel, increases the vegetable oil supplies which in return reduces its costs. Biodiesel has substantial carbon benefits and the best ratio of energy input to energy output of any liquid fuel. Biodiesel is already one of the most environmentally friendly fuels available, and as the industries are growing to greater extent, biodiesel continue to play important role in benefitting the environment. According to U.S. Department of Agriculture and Energy, biodiesel has potential of reducing CO_2 life cycle about 78%. The biodiesel diesel considerably reduces emissions and residuals such as unburned hydrocarbon and carbon monoxide to atmosphere [10].

Crude palm oil as a feedstock for the future of biodiesel industry is subject to disadvantages for Malaysia as the CPO prices are grown to be too high thus escalating the other oil prices in the commodity market, low profit margin since 90% of the production cost has to be allocated for the palm oil feedstock and the priority given by the Malaysian government to devote 40% of the total palm oil production for biodiesel production. The disadvantages with current palm oil biodiesel has made the Malaysian government to reassess the feedstock for production of biodiesel with a registered blend, research has already begun for the alternative feedstock. The safe replacement and cheaper feedstock after palm oil is called "Jatropha Curcus Linn", which has already been used by the Japanese at the time of World War II in order to serve as ignition fuel for the aircrafts which were operating at that point of time.

The main reason for using Jatropha seeds instead of other linseed oil, groundnut oil and soy oil is because of the environmental property which does not affect the nature. Jatropha is non-edible oil which makes it an advantage as biodiesel industry would not have to compete with food industry for its oil. Plantation for jatropha can be easily started in non-cropped insignificant lands and wastelands. These characteristics make Jatropha highly regarded as the second generation biodiesel [30]. Already developed countries use jatropha to mix with the petrol in order to arrive at a standard blend. The age of jatropha tree will be for a minimum of 25 years making it easier to be renewable from there on. Undoubtedly Malaysia is going to focus on Jatropha for the following factors; lower production cost, barrier for escalation of vegetable oil prices in accordance with palm oil, addresses the global demand for biodiesel since Malaysia and Indonesia are the top global biodiesel suppliers. This provides a safe environment by cutting down the carbon emissions. Jatropha can be further developed and mass oil production will bring a positive growth and development for biodiesel. Jatropha oil biodiesel has high potential to be the next sustainable energy security for future.

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